The Destruction of Wooden Paving Blocks by the Fungus Lentinus Lepideus, Fr.

IMPERIAL BUREAU
21 NOV. 1921
OF MYCOLOGY

BY

A. H. REGINALD BULLER, D.Sc., Ph.D.

Reprinted from

THE JOURNAL OF ECONOMIC BIOLOGY, 1905, vol. i, pt. 1.

THE DESTRUCTION OF WOODEN PAVING BLOCKS BY THE FUNGUS LENTINUS LEPIDEUS, Fr.[1]

By

A. H. REGINALD BULLER, D.Sc., Ph.D.,

Professor of Botany in the University of Manitoba.

With Plates I and II.

Whilst crossing Victoria Square, Birmingham, in the autumn of 1903, I noticed that a considerable number of the wooden paving blocks were becoming rotten. Although the great majority of the blocks were apparently quite sound, one could observe at intervals of a few feet or yards single blocks, or small groups of blocks, which on account of their softness had been beaten down to a lower level than the others, and were evidently in an advanced state of decay (Pl. II, figs. 14 and 17). The bumpiness resulting was noticeable to cyclists and others, while in wet weather puddles collected above places where the rotten blocks were. A similar condition of the pavement was to be seen in a number of the streets of Birmingham, the decay involving many thousands of the blocks.

The paving blocks used in the pavements consist of pinewood, and measure 9 × 6 × 3 inches. They are made from the centre of the tree-trunks. The grain is vertical (Pl. II, fig. 15). Before being laid down the blocks were "pickled," *i.e.*, dipped in creosote. This substance, however, had penetrated into the wood only very superficially. The blocks were placed upon a concrete foundation, and a space of a quarter of an inch in width left between them. Tar was then poured on above until the space was filled to a height of about one inch. The rest of the space between the blocks was afterwards filled with cement grout—a mixture of sand and cement—(Pl. II, figs. 16 and 17). The pavements were made 11 to 14 years ago.

In January of last year the bumpiness of the pavement in many places had become so marked, owing to the increase of the rotten blocks, that repairs had to be undertaken. The rotten blocks were taken up and new ones put in their place. I examined the rotten blocks as they were removed. They were usually split into pieces. The sur-

[1] This paper was written in the autumn of 1904, but owing to my removal to Canada its publication has been delayed.

For a further paper dealing with the reactions of the fruit bodies of the fungus to external stimuli see Annals of Botany, 1905, vol. xix, pp. 427-438, pls. xxiii-xxv.

faces so exposed were frequently covered over with a thin white layer of fungus mycelium (Pl. I, figs. 1 and 2). The wood in many cases was so rotten that it could be broken up into tiny fragments with the fingers.

About twenty of the blocks were removed to the laboratory and placed in a large damp chamber having glass sides and top (3 × 2.5 × 2.5 feet). In the course of three weeks some curious conical protuberances, evidently the fruit bodies of a fungus, began to grow out from several of the blocks (Pl. I, figs. 8 and 11). The damp chamber was then removed to a lighter position, and in the course of a few days pilei began to develop (Pl. I, figs. 3, 4, 5, 6, 11, and 12). The fungus was then identified as *Lentinus lepideus*, Fr.

A number of the rotting blocks were obtained in May near the Town Hall. Fruit bodies of *Lentinus lepideus* developed on them also. Altogether I have succeeded in raising the fruit bodies of this fungus on about twenty-five blocks. On some of the extremely rotten blocks no fruit bodies developed at all. The mycelium, although present in these cases also, appeared to be dead.

No other fruit-bodies beside those of *Lentinus lepideus* developed on any of the rotten blocks. At present therefore only one species of fungus has been identified as being concerned in the destruction of the pavement.[1]

In July, I made a visit to a wharf where some thousands of broken blocks, taken from one of the streets of Birmingham, had been placed in a pile some months before. Many of the blocks had been rotted in the manner which is characteristic for *Lentinus lepideus*, and on several I recognized the abortive fruit-bodies of the fungus (Pl. I, fig. 9). The conditions for their development as regards moisture and light had evidently been unfavourable.

From the foregoing observations the conclusion seems to me justified that the destruction of a considerable number of paving blocks in the City of Birmingham is being brought about solely by *Lentinus lepideus*.

The principal streets of our large towns are now to large extent paved with wood. The cost of such paving and the inconvenience of repairs are only too well known to the public. The destruction of paving blocks by fungi is, then, not only a matter of scientific interest but also of considerable economic importance. As *Lentinus lepideus* has proved to be an active agent in destroying numerous paving blocks

[1] Since writing the above I have been able to investigate a further set of rotten blocks obtained from another part of the town. The fruit-bodies of a species of *Corticium* developed on them instead of *Lentinus lepideus*. The rot was of a different character to that produced by the latter fungus. My removal from Birmingham has prevented me from proceeding any further with these observations.

in at least one town, it has seemed to me desirable to work out its biology with a view to preventing its ravages. So far as I am aware, the destruction of paving blocks by fungi has hitherto remained uninvestigated. There seems to be no literature on the subject.

Lentinus lepideus is one of the Agaricini. It lives exclusively on wood. Like the Dry Rot Fungus (*Merulius lacrimans*) it appears, at least in the Midlands, to be associated with timber used for building purposes, and is rarely or never to be found in the open. Mr. W. B. Grove, who for more than twenty years has studied the Midland fungus-flora, informs me that he has found *Lentinus lepideus* only on three occasions in this district: once in a cellar in the heart of Birmingham; once in a tanyard, and once in a wooden railway bridge in one of the suburbs. In other parts of the country he has observed the fungus in similar situations, and never in woods. I myself have only found it on the paving blocks. However, Mr. A. Titley has recently brought to my notice a specimen growing in the wood-work of a greenhouse at Sutton Coldfield. The monstrous forms figured in Cooke's Illustrations of the British Fungi were obtained in a brewery cellar at Burton.[1] According to the description in Massee's British Fungus-Flora,[2] however, the fungus occurs "on trunks, stumps, etc." Stevenson [3] states that it grows "on pine," and Cooke [4] on "stumps of firs, etc." Its natural habitat, therefore, appears to be coniferous woods.

The spores are colourless, smooth, and narrowly elliptical (Pl. II, fig. 18). They measure 10—8μ × 4·5—3μ. Germination was observed in hanging-drop cultures. In distilled water or tap-water the spores remain unchanged, but germinate readily in Pasteur's Fluid or in beef-gelatine. They also germinate in decoctions of pine-wood and of horse-dung. Owing to the deposition of horse-dung in our streets the conditions for spore-germination upon the paving blocks in rainy weather would seem to be well provided.

In Pasteur's Fluid the spores germinate within 24 hours. As a rule germ-tubes are put out successively at both ends of the spore, and but very exceptionally at the side (Pl. II, fig. 19). The germ-tubes soon become almost as thick as the spores. After a few days' growth it is difficult or impossible to distinguish the position of the spore in the mycelium (Pl. II, fig. 20). The germ-tubes branch and the lateral branches grow relatively far before rebranching. The appearance of the mycelium after two and a half days is shown in fig. 20, and after five days in fig. 21.

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[1] M. C. Cooke, Illustrations of British Fungi, pl. 1141.
[2] G. Massee, British Fungus-Flora, vol. ii, p. 313.
[3] J. Stevenson, Mycologia Scotica, 1879, p. 120.
[4] M. C. Cooke, Handbook of British Fungi, 2nd ed., p. 355.

A similar development took place in beef-gelatine (Pl. II, figs. 22 and 23). Plate and tube cultures were made. The mycelium grew slowly. Each spore gave rise to a plant about 12 millim. across in the course of a month. No signs of the mycelium breaking up into oidia or of their producing conidia could be observed.

The mycelium occurs in abundance in the cells of the rotting wood (Pl. II, fig. 24). The hyphae branch occasionally, and are provided with clamp connections (*c.*). Frequently the hyphae become coated with crystals of calcium oxalate (*o.*). In some cases a trail of crystals could be observed, although the hypha from which the salt had been excreted was not to be discovered, and seemed to have disappeared (*t.*). Similar trails of crystals were observed by Robert Hartig [1] when investigating the destruction of wood by *Merulius lacrimans*.

The hyphae in passing from tracheide to tracheide sometimes make their way through the cell-walls at the bordered pits (*p.*). Frequently, however, holes are made by the hyphae in walls where there are no pits (*h.*). Such holes become larger than the diameter of the hyphae. In this respect *Lentinus lepideus* differs from *Merulius lacrimans*.[2]

Macroscopically the very rotten wood resembles that rotted by *Merulius lacrimans*. This is doubtless the explanation of the statement, made to me by some workmen, who had had much experience in repairing work, that the pavement suffered from Dry Rot. The wood becomes red. When wet it is very spongy, so that it quickly soaks up water, which can be squeezed out again with the hand. A pencil is easily poked through the wood. Upon drying it shrinks very considerably, and cracks both longitudinally and transversely (Pl. I, fig. 10). It also becomes so extremely brittle that one can powder it up into the finest fragments with the fingers. The thin coating of mycelium, which one sees on breaking open a block freshly obtained from the street, is formed in the spaces left by the cracking of the wood during shrinkage (Pl. I, figs 1 and 2).

Examined with the microscope the tracheides, except for holes made in them by fungus hyphae, appear to be left intact (Pl. II, fig. 24). The middle lamella is not destroyed, so that the cells do not separate from one another. The secondary thickening appears to have undergone no change. Wood cells acted on by *Merulius lacrimans* present similar characters.[3] The medullary ray cells are devoid of starch grains, but often contain contents (*ptp.*) which resemble protoplasm in appearance.

The rotten wood is much lighter than the sound. It is quite

[1] R. Hartig, Der ächte Hausschwamm, Berlin, 1885, p. 12 ; also Taf. 1, fig. 2.
[2] R. Hartig, *loc. cit.*, p. 11.
[3] R. Hartig, *loc. cit.*

evident, therefore, that a considerable amount of substance has been removed by the fungus from the cell-walls.

On testing for hadromal [1] with phloroglucin and hydrochloric acid, every tracheide in the most rotten wood was found to turn a bright red. Some rotten wood was then ground up to a fine powder and left to soak in cold water for several days. The filtered extract did not show the phloroglucin reaction. Some of the powder was then placed in 90 per cent. alcohol for an hour. At the end of that time the filtered extract gave a bright red colour with the phloroglucin test. In the course of 24 hours' extraction with the alcohol the extract became yellowish in colour, and then gave an intense red reaction with phloroglucin and hydrochloric acid. If the phloroglucin test is to be relied upon, it seems, therefore, that hadromal is left behind in considerable quantities in the cell-walls. Hadromal is also left behind in wood rotted by *Merulius lacrimans*.[2]

The fresh pine-wood turns green with phenol and hydrochloric acid, and yellow with analine sulphate and sulphuric acid. As the wood becomes rotten it ceases to give these reactions. The alcoholic extract of the rotten wood also gives negative results. Wood acted upon by *Merulius lacrimans* similarly ceases to give the phenol reaction.[3]

The most rotten wood was then treated with Schulze's maceration fluid. The wood dissolved away rapidly. The fragments left were tested with chlor-zinc iodine. Here and there a few fragments of cell-walls stained blue. It became evident, however, by comparison with sound wood, which had been macerated in a similar manner, that the very rotten wood contains scarcely more than a trace of cellulose. *Merulius lacrimans* also removes the cellulose from the wood.[4]

Lentinus lepideus and *Merulius lacrimans* act upon coniferous wood not only physically but also chemically in a very similar manner. Both fungi destroy the cellulose and leave behind a red friable substance, which contains hadromal.

The fruit-bodies of *Lentinus lepideus* as a rule have no chance of developing in the streets, owing to the traffic above the pavement and want of space below it or between the blocks. However, they readily developed when rotten blocks were placed in a damp-chamber in a well lighted position. About 14 days after the rotten blocks were obtained from the street a snow-white mycelial covering grew out upon the surface of the blocks, especially on surfaces exposed by breaking

[1] Czapek, Zur Biologie der holzbewohnenden Pilze. Ber. d. D. Bot. Gesell., 1899, Bd. 17, pp. 166-170.

[2] R. Hartig, *loc. cit.*, p. 53; and Czapek, *loc. cit.*

[3] R. Hartig, *loc. cit.*, p. 53.

R. Hartig, *loc. cit.*, p. 54.

(Pl. I, figs. 6 and 8). About two days afterwards a number of small white papillae—the beginnings of the fruit-bodies—began to develop on the mycelium.

The papillae often arise in considerable numbers side by side. They develop into conical protuberances, at first quite devoid of pilei (Pl. I, figs. 8 and 11). In two instances similar conical protuberances were actually found on some paving blocks as they were removed from Victoria Square. They had formed in crevasses, between the blocks in one case, and below in the other.

A pileus forms on the end of each conical protuberance (Pl. I, fig. 11). Massee, in describing the fungus, mentions a "veil very soon disappearing."[1] In my specimens no trace of a veil could be seen. The pileus is gymnocarpous from the beginning. The gills are never hidden in a gill chamber. Stages in the formation of a fruit-body are shown in figs. 11 and 25. As the pileus grows larger decurrent gills are formed, which develop torn edges as in all the species of *Lentinus* (Pl. I, fig. 3). The mature fruit-bodies are very variable in shape, the variations depending largely on external conditions, especially light (*cf.* figs. 3, 4, and 7). The reactions of the fruit-bodies to external conditions are, however, treated of in another paper.[2]

The hymenial layer upon the gills contains basidia and paraphyses (Pl. II, figs. 26 and 27 *b.* and *p.*). The former bear four sterigmata (*st.*) which give rise to the four spores (*s.*). The paraphyses (*p.*) are very similar to the basidia but are not so broad at the ends. Cystidia are absent.

The colourless spores are shed in vast numbers. A full-sized pileus probably produces several million of them. As is the case with most Agaricini, the spores are scattered by the wind which doubtless can carry them long distances without injury.

The chief factor in the destruction of paving blocks made of pine-wood seems to be mechanical erosion. The blocks get worn down in Birmingham in busy streets at the rate of a quarter of an inch per annum. Some blocks in my possession were originally 6 inches thick. In the course of about fourteen years they were reduced to 2.5 inches in thickness (Pl. I, fig. 13). When they were removed at the end of that period they were quite sound, and unattacked by fungi. Mechanical erosion causes the blocks to wear out fairly evenly. *Lentinus lepideus*, by rotting particular blocks, shortens their period of usefulness and causes holes and bumpiness in the pavement. The fungus, therefore, by its action necessitates a large number of repairs which would not have to be undertaken if mere wear and tear of street traffic were the only factors in the destruction of the blocks.

[1] G. Massee, British Fungus-Flora, vol. ii, p. 313.

[2] *Loc. cit.*

When the blocks are laid down they have been already dipped in creosote, and are taken to the streets in a fairly dry condition. It seems probable that the blocks at that time are not yet infected with *Lentinus lepideus*. For several years after they have been laid down the blocks appear to remain quite sound. Then some of them begin to go rotten. As the pavement gets older more and more blocks decay, until in the course of something like ten years some thousand may be affected and periodic repairs have to be undertaken. Infection may well take place in some cases from spores which fall into cracks in the wood. I have noticed cracks in some blocks in great numbers on hot days. The creosote only makes its way into the wood to a depth of between one-eighth and one inch, so that cracks would not have to be very deep for spores to fall below the creosoted part.

In the course of a few years the upper creosoted layer of the pavements becomes worn off by the traffic. Small pebbles, sand, etc., get pressed into the blocks above. Except where these obstacles act as a hindrance, spores can come in direct contact with the uncreosoted wood. It seems to me probable that the obstacles mentioned afford a good deal of protection against infection by means of fungus spores.

Whence come the spores? It has been observed that the fruit-bodies of the fungus occur on timber associated with buildings, and are to be found in cellars, on wooden bridges, in wood-yards, etc. All sorts of wood-work are constantly being carried through the town. Spores may be blown from rotten wood-work removed during repairs, whilst it is being carried through the streets. The wind may bring spores directly from the various places, perhaps including pine and fir woods, where the fruit-bodies come to maturity. Possibly spores are contained in the horse-dung. To account for the infection of so many blocks in so many streets one must suppose that the spores are plentifully scattered over the pavement.

Since, as already mentioned, the spores germinate in various nutrient media, including decoctions of pine-wood and of horse-dung, they probably germinate readily enough in contact with the wood in wet weather. The mycelium probably grows in a block for some years before the latter is thoroughly rotted. Infected blocks usually become rotten at one end or on one side first (Pl. II, fig. 14 *a. b.*). The decay then gradually spreads over the whole block. The reduction in the specific gravity of the blocks, one may perhaps suggest, is chiefly due to the carbohydrates in the cell-walls being ultimately split up into water and carbon dioxide during the respiration of the fungus.

Although the mycelium grows luxuriantly in the pavement, no fruit-bodies are formed, for mechanical reasons, as already mentioned. There is, therefore, no reason to suppose that a rotten block by means of spores can infect other sound blocks not adjacent to it. The ques-

tion, however, arises as to whether a rotten block may affect its immediate neighbour by means of its mycelium. In many cases single blocks are found to be quite rotten, and the adjacent ones quite sound. Here one must conclude that, although the mycelium has been growing in the rotten block for a long period of time, probably years, owing to the perfect insulation of the rotten block by the tar, cement grout and creosote (Pl. II, fig. 17), infection of the neighbouring sound blocks has been prevented. On the other hand one frequently finds small groups of two, three, or more rotten blocks together. In such cases, *e.g.*, at *e*, *f*, *g*, and *h*, in figure 14, it seems fairly certain that local mycelial infection has taken place. That one rotten block infects its neighbour in the course of time is also a view held by several workmen, very experienced in road repairing, of whom I made enquiries. In some instances, as rotten blocks were being taken up, I actually saw the mycelium growing beneath the blocks over the creosoted surface. Any fault in the laying or wearing of the blocks might easily lead to the infection of neighbouring blocks.

The constant watering of the streets is probably an important factor in maintaining the existence of the fungus in the blocks. When a block has begun to rot it soon gets beaten down to a lower level than the sound blocks. In consequence of the presence of a single rotten block a shallow depression, involving the adjacent sound blocks, is made by the traffic (Pl. II, fig. 17), and a puddle is formed whenever rain falls or the street is watered. The water is rapidly soaked up by the rotting wood. The blocks, therefore, rarely have a chance to dry, and the fungus escapes desiccation accordingly. Whether desiccation kills the mycelium is a question which I have not yet succeeded in answering.

Several persons engaged in the road repairing have informed me that, the less a street is used, the more it suffers from rotting of the blocks. The worst infected street known to me is very little used. Assuming that traffic is inimical to infection of the blocks by the fungus, the explanation of the fact does not seem very clear.

Judging from the numbers of repairs that are constantly being made on account of the ravages of *Lentinus lepideus* or other wood-destroying fungi, the cost of treating the blocks with an antiseptic, with a view to preventing the growth of the fungus, is well worth considering. I found that the thin outer layer of wood, which has been impregnated with creosote in a dipped block, often remained quite sound, when the rest of the wood had become quite rotten. This fact and also results obtained with railway sleepers [1], clearly indicate that *Lentinus lepideus* or any other wood-destroying fungus could be kept out of

[1] Hermann von Schrenk, The Decay of Timber and Methods of Preventing it. Washington, 1902, pp. 49-51.

paving blocks by fully impregnating the latter with creosote. Already fully creosoted blocks are being made in large numbers for the pavement of towns, but are by no means universally used. A large number, amounting to hundreds of thousands, are shortly to be laid down in Birmingham.

On enquiring of a road surveyor what advantage the fully creosoted blocks have over the dipped blocks, the answer was that the creosote keeps out the water and thus prevents decay. The creosote, however, as my investigations show, must act by keeping the blocks free from wood-destroying fungi. Possibly a cheaper treatment than creosoting might be devised for this purpose.

The extra cost of fully creosoted blocks, over those which are merely dipped in creosote, is considerable. Blocks are now supplied into which 8, 12 or 16 lbs. of creosote have been compressed per cubic foot. When only 8 lbs. of creosote have been pressed in per cubic foot, according to a calculation kindly communicated to me by Mr. John Price, the Surveyor for the City of Birmingham, about 15 per cent. is added to the cost of the pavement. Whether the saving in repairs, owing to use of such blocks, would more than compensate for the extra initial cost of the latter is a question which must be left to surveyors, engineers, and others, whose business it is to lay down pavements, with due regard to economy and the public convenience.

These investigations were carried out at the University of Birmingham, and I have much pleasure in expressing my best thanks to Professor Hillhouse for allowing me the use of the photographic and other resources of the Botanical Laboratory.

SUMMARY.

1. The destruction of a large number of paving blocks, made of pine-wood, in the City of Birmingham, is being brought about by *Lentinus lepideus*, a fungus belonging to the Agaricini. Considerable repairs to the pavement are thereby necessitated.

2. Single blocks, or small groups of blocks at intervals in the streets go completely rotten, so that one can break up the wood with the fingers. The streets affected become unduly bumpy. In wet weather puddles collect above places where rotten blocks are.

3. A number of rotting blocks, obtained from time to time from the streets, were placed in a large damp-chamber. In the course of a few weeks fruit-bodies of *Lentinus lepideus* appeared upon them.

4. The spores remain unchanged in distilled water and tap-water, but germinate readily in Pasteur's Fluid and in beef-gelatine. They also germinate in decoctions of horse-dung and of pine-wood.

5. The pavement is probably infected by spores after the blocks

have been laid down. The mycelium often grows from a rotten block to the neighbouring sound ones. No fruit-bodies are produced in the streets owing to the traffic.

6. The wood is rotted by *Lentinus lepideus* in very much the same manner as by *Merulius lacrimans* (the Dry Rot fungus). It becomes red, and is spongy when wet. It shrinks and cracks considerably on drying, and is then very brittle and friable. Cellulose is removed from the cell-walls and hadromal left behind.

7. The paving blocks, used in the pavements referred to, were dipped in creosote before use. Had they been fully impregnated with that substance, the ravages of *Lentinus lepideus* or any other wood-destroying fungus would have been prevented.

EXPLANATION OF PLATES I AND II.

Illustrating Professor Buller's paper on "The Destruction of Wooden Paving Blocks by the Fungus *Lentinus lepideus*, Fr."

Plate I.

Figs. 1 & 2.—Mag. $\frac{1}{4}$. Rotten blocks of Pine just removed from a street pavement. The white mycelium of *Lentinus lepideus* is seen on the surfaces exposed by breaking the blocks.

Fig. 3.—Nat. size. Fruit-body of *Lentinus lepideus* growing out of a paving block. The gills are broad, decurrent, and have torn edges. Two drops have been excreted by the gills.

Fig. 4.—Nat. size. Another fruit-body of *Lentinus lepideus*. The stipe is long. The pileus is chiefly developed on the side toward the observer.

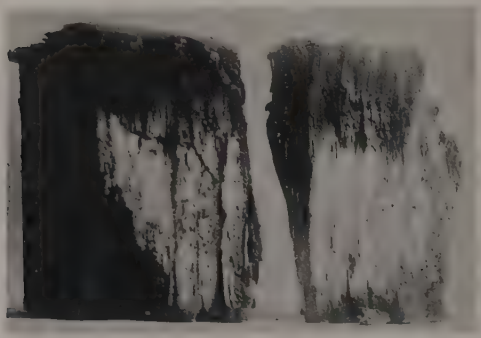
Fig. 5.—Mag. $\frac{1}{4}$. The paving block upon which grew the fruit-body of fig. 4.

Fig. 6.—Mag. $\frac{1}{4}$. The paving block upon which grew the fruit-body of fig. 3.

Fig. 7.—Nat. size. A fruit-body. The gills are equally developed all round the pileus.

Fig. 8.—Mag. $\frac{3}{8}$. Paving block upon which monstrous fruit-bodies have developed in the dark. A white mycelial covering is to be seen upon the wood surface. The covering produced papillæ which grew into the conical protuberances and rods. There are no pilei.

Fig. 9.—Mag. $\frac{5}{12}$. Paving block found among a pile of blocks which had been removed from a street in Birmingham. To the left is a monstrous fruit-body of *Lentinus lepideus*. It is branched like an elk's horn and is without a pileus.



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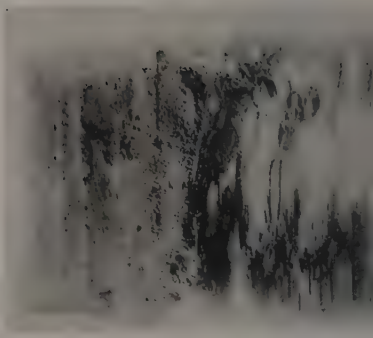

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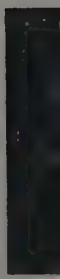

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THE DESTRUCTION OF PAVING

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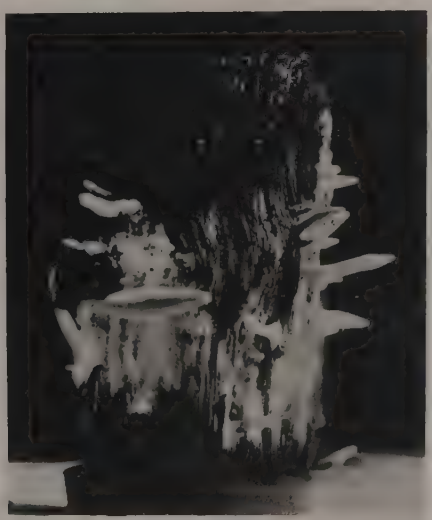

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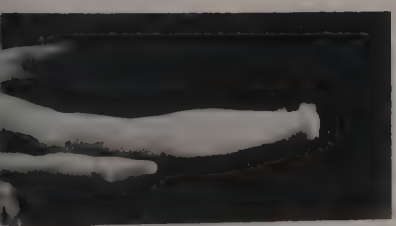

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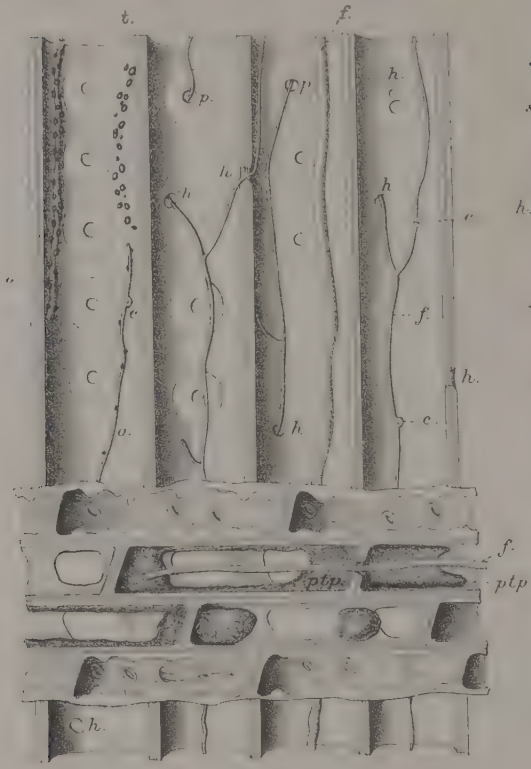

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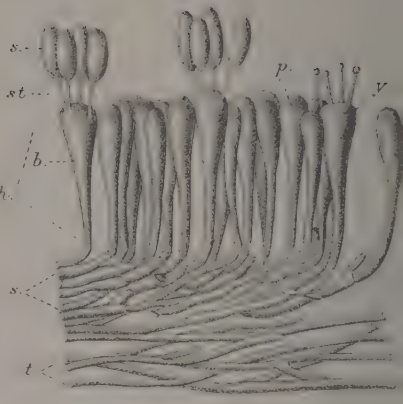

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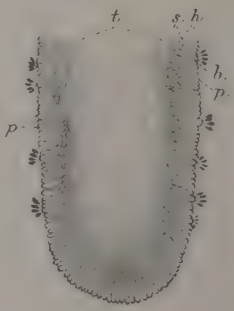

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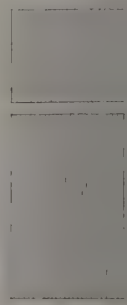

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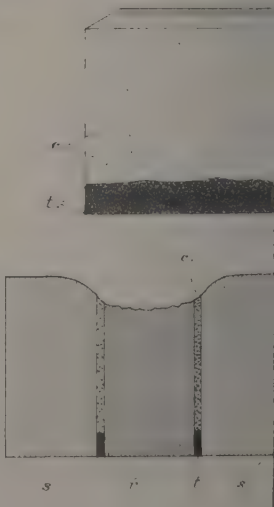
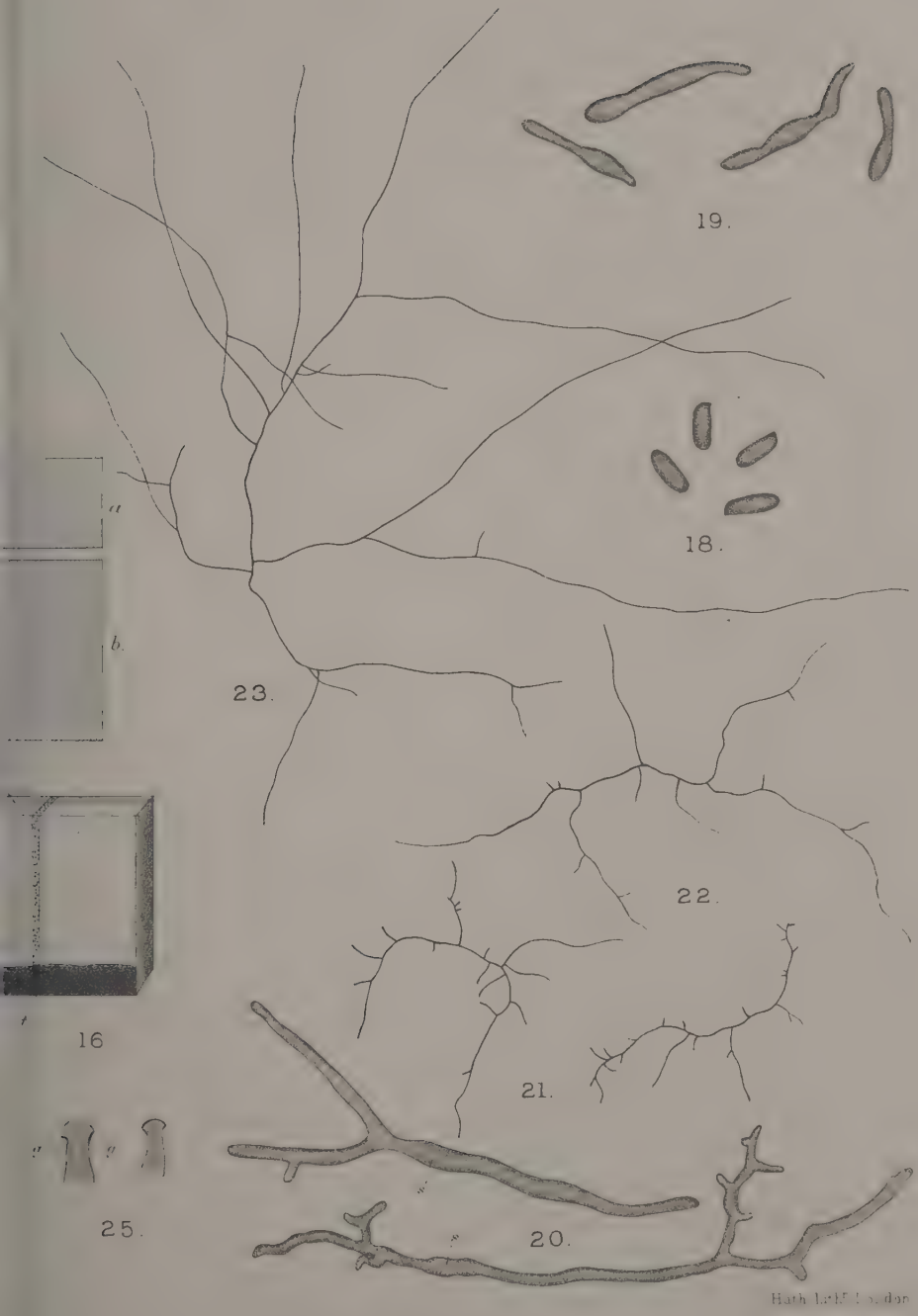


A.H.R.B. del. ad nat.

THE DESTRUCTION OF PAVING



OCKS BY LENTINUS LEPIDEUS, Fr

Fig. 10.—Mag. $\frac{3}{8}$. Paving block rotted by the fungus and then allowed to dry. Transverse and longitudinal cracks have formed in the wood owing to shrinkage.

Fig. 11.—Nat. size. Three young fruit-bodies grown in moderate light. The uppermost one is aborted, and has ceased its development. The lowest one still shows no signs of a pileus. The middle one is producing a pileus, upon which drops of water have been excreted. The whole group is photographed from below. The middle fruit-body developed into that in fig. 7.

Fig. 12.—Mag. $\frac{1}{6}$. In the centre a paving block from which developed the fruit-body of fig. 7. To the left, a block producing several young fruit-bodies with rudimentary pilei.

Fig. 13.—Mag. $\frac{1}{6}$. In the centre is a new paving block which measured 6 inches in height. To the right and left are two blocks, originally of the same height as the centre block. During about 14 years, whilst forming part of the pavement in Broad Street, Birmingham, $3\frac{1}{2}$ inches of wood were worn off them by mechanical erosion. The wood remaining was quite sound.

Plate II.

Fig. 14.—Mag. $\frac{1}{18}$. Diagram of pavement to illustrate occurrence of rotten blocks. At *a*, *b*, and *c*, blocks are beginning to decay. The blocks *d.d.* are quite rotten, but have not infected their neighbours. At *e*, *f*, and *g*, groups of rotten blocks are seen. At *h* are two quite rotten blocks, the block between being rotten only at the ends in contact with the rotten blocks.

Fig. 15.—Mag. $\frac{1}{6}$. The top, *a*, and side, *b*, of a typical paving block, showing the direction of the grain.

Fig. 16.—Mag. $\frac{1}{6}$. A whole block on the left, and part of a block on the right, showing how the blocks are packed. The space between the blocks is filled up with tar, *t*, and cement grout, *c*.

Fig. 17.—Mag. $\frac{1}{6}$. A rotten block, *r*, in the centre, and two sound blocks, *s.s*, right and left. The depression in the pavement involves the edges of the sound blocks. A puddle forms in the depression in wet weather; *c*, cement grout; *t*, tar.

Fig. 18.—Mag. 600. Spores of *Lentinus lepideus*.

Fig. 19.—Mag. 600. Germinating spores after 23 hours in Pasteur's Fluid.

Fig. 20.—Mag. 600. Germ-tubes 54 hours after the spores were placed in Pasteur's Fluid; *s.s*, the position of the spores.

Fig. 21.—Mag. 160. Two young plants 5 days after the spores were placed in Pasteur's Fluid.

Fig. 22.—Mag. 160. Development of mycelium from a spore during 5 days in beef-gelatine.

Fig. 23.—Mag. 160. Development during 8 days in beef-gelatine.

Fig. 24.—Mag. 450. Radial-longitudinal section of wood of Pine from a rotten paving block. A medullary ray is represented crossing four tracheides. The hyphae, *f.f*, of *Lentinus lepideus* are to be seen in the cell lumina. The hyphae are sometimes branched, and are provided with clamp connections, *c.c*. The hyphae make their way from cell to cell through bordered pits, *p.p*, or bore holes through the walls, *h.h*. Some hyphae are coated with crystals of calcium oxalate, *o.o*. At *t*, the hyphae has disappeared, and a trail of crystals have been left behind. Cell contents looking like protoplasm, *ptp*, are left behind in some of the medullary ray cells.

Fig. 25.—Nat. size. Very young fruit-bodies. The pileus is just beginning to be formed. It is gymnocarpous, *g.g*, the rudimentary gills not enclosed in a gill-chamber.

Fig. 26.—Mag. about 85. A semi-diagrammatic section through one of the gills of *Lentinus lepideus*. The hymenium, *h*, contains paraphyses, *p*, and basidia, *b*. Each basidium produces four sterigmata and four spores; *s*, sub-hymenium; *t*, the trama.

Fig. 27.— Mag. 600. Section through the hymenial surface of a gill; *t*, the trama; *s*, the sub-hymenium; *h*, the hymenium; *b*, basidium; *st*, sterigmata; *s*, spore; *y*, young basidium with four rudimentary spores; *p*, paraphyses.